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school is clear. Internal factors and felt needs are the springs of successful activity on the part of the children, and when you talk of training a child's power of observation, you may profitably keep in mind the possibility of cultivating his powers of purposeful action, success in which will depend upon watchfulness and care in the use of his senses. When mistakes in observation really matter, they become relatively infrequent. Many of the school observation lessons are, psychologically considered, nothing more than a formal attempt to associate names to things or to the specific sensory qualities of things. Whether they are justified or not it is not the business of psychology to say.

At the same time, the psychological qualities of a good observer include something more than interest in and knowledge of the subject under examination. Interest in a subject is not infrequently accompanied by preconceptions which may even be strong enough to vitiate the observations altogether. Until Galileo's time, people believed that a stone of ten pounds weight would fall ten times more quickly than a stone of one pound. That was the current belief, and nobody thought of questioning it. Yet the actual fall of stones must have been watched many times in the interval, but it was only with difficulty that Galileo persuaded his contemporaries to look at facts in freedom from the bias of preconception. In a like way, every teacher of science knows how difficult it is to prevent the quite honest "cooking" of results which comes when a pupil knows beforehand what he ought to find. Hence to train observation implies also a training in intellectual honesty and serves to lay the foundation of a love of truth for its own sake, which enables one to recognize facts whether or not they are in accordance with the preconceived ideas or hopes.

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ON THE CONSTRUCTION OF A NON-ARISTOTELIAN LOGIC.

In a paper read at the Christmas meeting of the American Philosophical Association at Princeton University in December 1917,[1] the writer pointed out the existence of a group of logics, in which many of the implications of the traditional science become untrue.

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[1] See also the writer's *Primer of Logic,* (B. D. Smith and Brothers, Pulaski, Va., 1917).

The members of this family are each one more general than the common logic, while certain of their underlying axioms stand in contradiction to one another. It is proposed now to construct in some detail that member of the group, whose characteristic postulate asserts the untruth of the proposition, *all a is all a,* for all meanings of *a.* In order to keep the discussion within the narrowest limits consistent with its purpose, we shall confine our attention as far as possible to a single type of implication. Because of the central importance of the syllogism in any system of inference, it will be deemed enough to deduce all the true and all the untrue propositions of that type.

There are four forms which the logician may recognize as necessary and sufficient to express the manner in which any two classes, *a* and *b,* may be related categorically. These will be represented by the letters α, β, γ and ϵ. Accordingly let

$\alpha(ab)$ = All *a* is all *b,*
$\beta(ab)$ = Some *a* is some *b,*
$\gamma(ab)$ = All *a* is some *b,*
$\epsilon(ab)$ = No *a* is *b,*

the word *some,* which is explicit in β and γ, being interpreted to mean *some at least, not all.* This meaning of the word is unambiguously established by the properties of the four forms.

By $x(ab)$, $y(ab)$ etc., we shall understand a proposition, which may take on any one of these four meanings, the *terms* being the *subject a,* which is written first, and the *predicate b,* which is written second. When it shall be necessary to indicate that one of these forms is false, we shall place a prime (′) to the right. Thus $x(ab)$ *is false* will be represented by $x'(ab)$, $[x'(ab)]'$ by $x''(ab)$. A comma between the terms will indicate that the term order is not settled. Accordingly $x(a, b)$ will stand either for $x(ab)$ or $x(ba)$.

In addition to the categorical forms the logician distinguishes,

1. the *Hypothetical* relationship,
   $x \angle y = x$ implies y,
   $(x \angle y)' = x$ does not imply y,
2. the *Conjunctive* relationship,
   $xy = x$ and y,
3. the *Disjunctive* relationship,
   $x + y = x$ or y.

By the *null-proposition* he understands an impossibility and by the *null-class,* a class, which contains no objects. By the *one-proposition* he understands a proposition, which is true in any given system of inference for all meanings of the terms and by the *one-class,* a class, which contains all the objects, which are in question. We shall denote the null-class and the null-proposition by the symbol o, the one-class and the one-proposition by the symbol i, and we shall from time to time replace the a and b, the x and y, by these special values. In every case it will be clear from the position of the symbol, whether class or proposition is meant.

The *syllogism* is a form of implication belonging to one of the types:

$$
\begin{gathered}
x(ba)y(cb) \angle z(ca), \\
x(ab)y(cb) \angle z(ca), \\
x(ba)y(bc) \angle z(ca), \\
x(ab)y(bc) \angle z(ca).
\end{gathered}
$$

These differences are known as the first, second, third and fourth *figures* of the syllogism respectively. The two forms conjoined to the left of the implication sign are called the *premises* and the form, which stands to the right of the implication sign, is called the *conclusion.* The predicate of the conclusion is called the *major term* and points out the *major premise* and the subject of the conclusion is called the *minor term* and points out the *minor premise.* The term, which is common to the premises and which does not appear in the conclusion, is called the *middle term.* The conjunctive relationship of logic being commutative, the order of the premises is indifferent, but, as a matter of convention, we agree always to write the major premise first. This will always be possible by applying the principle, $(xy \angle z) \angle (yx \angle z)$.

Since x, y and z may take on any one of the four values, α, β, γ, and ϵ, there will be sixty-four modes in each one of the four figures, in which $x(a,b)y(b,c) \angle z(ca)$ can be expressed. Each member of this *array* of syllogistic variations is called a *mood* of the array. The true propositions of the array are called *valid moods* of the array and the other moods are called *invalid moods* of the array.

The principles of deduction, which are given below and which we shall assume as necessity requires, are, of course, not all independent, but no attempt will be made here to point out their interconnection. We shall assume:

I[2] $(xy\angle z)(z\angle w)\angle(xy\angle w)$
$(xy\angle z)(w\angle x)\angle(wy\angle z)$
$(xy\angle z)(w\angle y)\angle(xw\angle z)$

II $(xy\angle z)\angle(xz'\angle y')$
$(xy\angle z)\angle(z'y\angle x')$

III $(xy\angle z)'(w\angle z)\angle(xy\angle w)'$
$(xy\angle z)'(x\angle w)\angle(wy\angle z)'$
$(xy\angle z)'(y\angle w)\angle(xw\angle z)'$

IV $(xy\angle z)'\angle(xz'\angle y')'$
$(xy\angle z)'\angle(z'y\angle x')'$

V $(x\angle y)\angle(y'\angle x')$
$(x\angle y')\angle(y\angle x')$
$(x'\angle y)\angle(y'\angle x)$

VI $(x\angle y)\angle(xy'\angle o)$
$(xy\angle o)\angle(x\angle y')$

VII $(x\angle y)(y\angle z)\angle(x\angle z)$

VIII $(x\angle y)\angle(wx\angle wy)$

IX $(x\angle y)(x\angle y')\angle(x\angle o)$
$(x\angle o)\angle(x\angle y)$

The valid moods of the array $x(a,b)y(b,c)\angle z(ca)$, (x, y and z representing only the unprimed letters), which number twenty-one in the system of inference we are about to construct, are all gotten by the aid of principles I from the postulates given below,[3] viz.

i. $\alpha(ba)\beta(cb)\angle\beta(ca)$
ii. $\alpha(ba)\epsilon(cb)\angle\epsilon(ca)$
iii. $\gamma(ba)\gamma(cb)\angle\gamma(ca)$
iv. $\gamma(ab)\epsilon(bc)\angle\epsilon(ca)$
v. $\beta(ab)\angle\beta(ba)$
vi. $\alpha(ab)\angle\alpha(ba)$

The valid moods of the arrays, $x(a,b)y'(b,c)\angle z'(ca)$ and $x'(a,b)y(b,c)\angle z'(ca)$, of which there are twenty-three and nineteen respectively, may be derived at once from the results now obtained by principles II.

The valid moods of the array, $x(a,b)y(b,c)\angle z'(ca)$, there being one hundred and fourteen of this type, may be obtained from those of the array, $x(a,b)y(b.c)\angle z(ca)$, by the aid of the additional postulates:[4]

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[2] Most of these principles are well known to logicians. I owe my knowledge of them for the first time—but more especially I owe my knowledge of the method here employed—to certain lectures of Prof. E. A. Singer, Jr., delivered at the University of Pennsylvania about ten years ago.

[3] The operation of *simple conversion* consists in the interchange of subject and predicate. Postulates v and vi express the simple convertibility of α and β. It should be pointed out that this same character may be proven of ϵ by the aid of the characteristic postulate, $i\angle\gamma(aa)$, (see below), as follows:

$\gamma(ab)\epsilon(bc)\angle\epsilon(ca)$ yields $\gamma(aa)\epsilon(ac)\angle\epsilon(ca)$, for $a=b$, and
$[\gamma(aa)\epsilon(ac)\angle\epsilon(ca)][i\angle\gamma(aa)]\angle[\epsilon(ac)\angle\epsilon(ca)]$

by the second member of I.

The non-convertibility of γ, expressed by $[\gamma(ab)\angle\gamma(ba)]'$, may be established at once by making $a=o$ and $b=i$, (see the characteristic postulates xi below).

$$
\begin{aligned}
&\text{vii.}\ \alpha(ba)\beta(cb)\angle\gamma'(ca)\\
&\text{viii.}\ \beta(ba)\,\alpha(cb)\angle\gamma'(ca)\\
&\text{ix.}\ \alpha(ba)\epsilon(cb)\angle\gamma'(ca)\\
&\text{x.}\ \alpha(ab)\angle\gamma'(ab)\\
&\qquad \alpha(ab)\angle\epsilon'(ab)
\end{aligned}
$$

The implications,

$$
\begin{array}{ll}
\alpha(ab)\angle\alpha''(ab), & \gamma(ab)\angle\gamma''(ab),\\
\beta(ab)\angle\beta''(ab), & \epsilon(ab)\angle\epsilon''(ab),
\end{array}
$$

which we should have to use in this connection may be established thus:

iii will yield $\gamma(ba)\gamma(bb)\angle\gamma(ba)$, for $b=c$, and
$[\gamma(ba)\gamma(bb)\angle\gamma(ba)]\ [i\angle\gamma(bb)]\angle[\gamma(ba)\angle\gamma(ba)]$, by I.
Also $[\gamma(ba)\angle\gamma(ba)]\angle[\gamma(ba)\gamma'(ba)\angle o]$, by VI,
and $[\gamma(ba)\gamma'(ba)\angle o]\angle[\gamma(ba)\angle\gamma''(ba)]$, by VI.

No valid implications of syllogistic form exist, other than the ones that have now been enumerated, as will appear later on, when all of the remaining variants shall have been declared untrue. It will be necessary at this point to state the characteristic postulates of the logic, which we have been constructing. It has not been essential to do this up to now, because every form of inference, which is valid here, is also valid in the common logic. They are required in order to establish the invalidity of those forms, which ordinarily taken to be valid, are invalid here. These characteristic postulates, which are, however, evidently not independent,[5] are:

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[4] It must be noticed that $\alpha(ab)\angle\beta'(ab)$ and $\alpha(ab)\angle\epsilon'(ab)$ may be derived from vii and ix respectively through the use of the characteristic postulate, $\gamma'(aa)\angle o$, as follows:

ix yields $\alpha(ba)\epsilon(ab)\angle\gamma'(aa)$, for $a=c$, and, by I,
$[\alpha(ba)\epsilon(ab)\angle\gamma'(aa)]\ [\gamma'(aa)\angle o]\angle[\alpha(ba)\epsilon(ab)\angle o]$.
Also $[\alpha(ba)\epsilon(ab)\angle o]\angle[\alpha(ba)\angle\epsilon'(ab)]$, by VI, and
$[\alpha(ab)\angle\alpha(ba)]\ [\alpha(ba)\angle\epsilon'(ab)]\angle[\alpha(ab)\angle\epsilon'(ab)]$, by VII.

A similar derivation will yield $\alpha(ab)\angle\beta'(ab)$.

From these two, together with x, by principle V, we obtain immediately,

$$
\begin{array}{ll}
\epsilon(ab)\angle\alpha'(ab), & \epsilon(ab)\angle\beta'(ab),\\
\gamma(ab)\angle\alpha'(ab), & \beta(ab)\angle\alpha'(ab),
\end{array}
$$

results which we have constantly to employ in conjunction with the valid moods of the array, $x(a,b)y(b,c)\angle z(ca)$, in order to obtain the valid moods of the array, $x(a,b)y(b,c)\angle z'(ca)$.

[5] The selection of these postulates, while in large measure arbitrary, has been such as not to contradict the definition of the null-class. Then o and ι in the parentheses refer, of course, to the null- and the one-class; the o to the right of the implication sign refers to the null-proposition.

$$\begin{array}{lllll}
\text{xi.} & \alpha(oo)\angle o & \alpha(oi)\angle o & \alpha(io)\angle o & \alpha(ii)\angle o \\
 & \beta(oo)\angle o & \beta(oi)\angle o & \beta(io)\angle o & \beta'(ii)\angle o \\
 & \gamma'(oo)\angle o & \gamma'(oi)\angle o & \gamma(io)\angle o & \gamma'(ii)\angle o \\
 & \epsilon'(oo)\angle o & \epsilon'(oi)\angle o & \epsilon'(io)\angle o & \epsilon(ii)\angle o
\end{array}$$

If we postulate in addition, $\alpha(aa)\angle o$ and $\gamma'(aa)\angle o$, the members of the following sets may be made to depend upon those which have just been written down, i. e.,

$$\begin{array}{ll}
\alpha(aa)\angle\alpha'(aa) & [\alpha'(aa)\angle\alpha(aa)]' \\
[\beta(aa)\angle\beta'(aa)]' & [\beta'(aa)\angle\beta(aa)]' \\
[\gamma(aa)\angle\gamma'(aa)]' & \gamma'(aa)\angle\gamma(aa) \\
[\epsilon(aa)\angle\epsilon'(aa)]' & [\epsilon'(aa)\angle\epsilon(aa)]' \\
 & \\
[\beta(ab)\angle\gamma'(ab)]' & [\gamma(ab)\angle\beta'(ab)]' \\
[\gamma(ab)\angle\epsilon'(ab)]' & [\epsilon(ab)\angle\gamma'(ab)]' \\
[\gamma(ab)\angle\gamma'(ba)]' &
\end{array}$$

In continuation of our task of deducing the invalid moods of the syllogism, it will be convenient to begin with the array, $x(a,b)y(b,c)\angle z'(ca)$. Ninety-six of the invalid moods of this type may be reduced to simpler invalid forms of inference already established, and so shown to be invalid, (1) either by identifying terms in a γ-premise or a γ- conclusion and suppressing the part $\gamma(aa)$, or (2) by replacing the subject and predicate of a β-premise or a β-conclusion by unity and suppressing the part $\beta(ii)$.[6] The

---

[6] (1) Suppose $\beta(ba)\gamma(cb)\angle\epsilon'(ca)$ to be a valid mood.

$\beta(ba)\gamma(cb)\angle\epsilon'(ca)$ yields $\beta(ii)\gamma(oi)\angle\epsilon'(oi)$ for $a=b=i,\ c=o$;
$[\beta(ii)\gamma(oi)\angle\epsilon'(oi)]\ [\epsilon'(oi)\angle o]\angle[\beta(ii)\gamma(oi)\angle o]$, by VII;
$[\beta(ii)\gamma(oi)\angle o]\angle[\beta(ii)\angle\gamma'(oi)]$, by VI.

But the last result is invalid and

$\therefore \beta(ba)\gamma(cb)\angle\epsilon'(ca)$ is invalid.

(2) Suppose $\beta(ba)\beta(bc)\angle\gamma'(ca)$ to be a valid mood.

$\beta(ba)\beta(bc)\angle\gamma'(ca)$ yields $\beta(ba)\beta(ba)\angle\gamma'(aa)$, for $a=c$;
$[\beta(ba)\beta(ba)\angle\gamma'(aa)]\ [\gamma'(aa)\angle o]\angle[\beta(ba)\beta(ba)\angle o]$, by VII;
$[\beta(ba)\beta(ba)\angle o]\angle[\beta(ba)\angle\beta'(ba)]$, by VI.

But the last result is invalid and

$\therefore \beta(ba)\beta(bc)\angle\gamma'(ca)$ is invalid.

The four non-implications,

$$\begin{array}{ll}
[\alpha(ab)\angle\alpha'(ab)]', & [\gamma(ab)\angle\gamma'(ab)]', \\
[\beta(ab)\angle\beta'(ab)]', & [\epsilon(ab)\angle\epsilon'(ab)]',
\end{array}$$

which we should continually have to employ in applying the method of the last example, may be established as follows:

$[\alpha(ab)\angle\alpha'(ab)]\angle[\alpha(ab)\alpha''(ab)\angle o]$, by VI;
$[\alpha(ab)\alpha''(ab)\angle o]\ [\alpha(ab)\angle\alpha''(ab)]\angle[\alpha(ab)\alpha(ab)\angle o]$, by I;
$[\alpha(ab)\angle\alpha(ab)\alpha(ab)]\ [\alpha(ab)\alpha(ab)\angle o]\ [\angle[\alpha(ab)\angle o]$, by VII;
$[\alpha(ab)\angle o]\angle[\alpha(ab)\alpha(ca)\alpha(cb)\angle o]$, by VIII;
$[\alpha(ab)\alpha(ca)\alpha(cb)\angle o]\angle[\alpha(ab)\alpha(ca)\angle\alpha'(cb)]$, by VI.

remaining forty-six invalid moods of this type may be derived from results already obtained by the aid of principles III and IV and the additional postulates.

xii. $[\alpha(ba)\alpha(cb)\angle\alpha'(ca)]'$ xiii. $[\alpha(ba)\epsilon(cb)\angle\epsilon'(ca)]'$
xiv. $[\alpha(ba)\beta(cb)\angle\beta'(ca)]'$ xv. $[\beta(ba)\beta(cb)\angle\epsilon'(ca)]'$
xvi. $[\alpha(ba)\gamma(cb)\angle\gamma'(ca)]'$ xvii. $[\gamma(ba)\alpha(cb)\angle\gamma'(ca)]'$

All but eight[7] of the two hundred and thirty-five invalid moods of the array, $x(a,b)y(b,c) \angle z(ca)$, may now be obtained, those of the arrays, $x'(a,b)y(b,c) \angle z'(ca)$ and $x(a,b)y'(b,c) \angle z'(ca)$ can be gotten at once by principles III and IV, and it will be easy to show that all of the two hundred and fifty-six moods of each one of the arrays $x'(a,b)y(b,c) \angle z(ca)$, $x(a,b)y'(b,c) \angle z(ca)$, $x'(a,b)y'(b,c) \angle z(ca)$ and $x'(a,b)y'(b,c) \angle z'(ca)$ are invalid, without making any further assumptions.

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But this last result contradicts postulate xii below.

$\therefore \alpha(ab) \angle \alpha'(ab)$ is invalid.

The second and third forms, $\beta(ab) \angle \beta'(ab)$ and $\gamma(ab) \angle \gamma'(ab)$, will be seen to be established as invalid on making $a = b = i$, and the last, $\epsilon(ab) \angle \epsilon'(ab)$, on making $a = b = o$.

[7] The mood $\beta(ba)\epsilon(cb) \angle \gamma(ca)$, which will have to be set down as a postulate, implies at once its own invalidity in the other three figures. The remaining four follow from $\gamma(ba)\beta(cb) \angle \beta(ca)$.

The two examples which follow will be enough to illustrate the method of deducing the moods of this array.

(1) $\alpha(ba)\beta(cb) \angle \beta'(ca)$ is an invalid mood.

$[\alpha(ba)\beta(cb) \angle \beta'(ca)]'[\alpha(ca) \angle \beta'(ca)] \angle [\alpha(ba)\beta(cb) \angle \alpha(ca)]'$, by III.

(2) Suppose $\alpha(ba)\beta(cb) \angle \gamma(ca)$ to be a valid mood.

$[\alpha(ba)\beta(cb) \angle \gamma(ca)]\ [\alpha(ba)\beta(cb) \angle \gamma'(ca)] \angle [\alpha(ba)\beta(cb) \angle o]$, by IX;
$[\alpha(ba)\beta(cb) \angle o] \angle [\alpha(ba)\beta(cb) \angle \alpha(ca)]$, by IX.

But $\alpha(ba)\beta(cb) \angle \alpha(ca)$ is invalid by the last example.

$\therefore \alpha(ba)\beta(cb) \angle \gamma(ca)$ is invalid.